

Genetic Correlations Among Body Condition Score, Yield and Fertility in Multiparous Cows Using Random Regression Models

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Introduction

Body Condition Score (**BCS**) is commonly used as an indicator of the extent and the duration of the postpartum energy balance. It is consequently related to production, fertility and health traits (Roche et al., 2009) and selection for improved BCS is considered as beneficial for cow robustness. Previous studies (e.g. Dechow et al., 2001; Berry et al., 2003; Pryce and Harris, 2006) estimated the genetic correlations among BCS, production and fertility traits but data were generally limited to first parity cows and BCS at different stages of lactation were often considered as different traits. The quality and the structure of Walloon data allowed estimating genetic relationships between BCS (as a longitudinal trait) and production and fertility (as traits that are measured as single lactation record) using multi-lactation random regression models. The interest of such models was the estimation of the change of the correlations within and across parities. The objective of this study was therefore to estimate genetic correlations between BCS (in lactation 1 to 3) and economically important traits (days open (**DO**), 305-days milk yield (**305MY**), 305-days fat yield (**305FY**) and 305-days protein yield (**305PY**)) using random regression models.

Material and methods

Data. Since April 2006, BCS has been monthly collected by milk recording agents in selected herds of the Walloon Region of Belgium. Dairy cows are given a BCS based on a nine-point scale (with unit increments). BCS were required to have been recorded between 5 and 365 days in milk (**DIM**) on lactating cows in parity 1 to 3. DO records were extracted from the official genetic evaluation database for cows in parity 1 to 3, born after 1996, and belonging to herds with at least one cow with both BCS and DO records. Milk, fat and protein yield cumulated at 305-d were estimated using the methodology presented by Gillon et al. (2009) for cows in parity 1 to 3, with lactation greater than 250 days, born after 1996, and belonging to herds with at least one cow with both production and BCS records. The analysis for BCS and DO included 12,481 cows (of which 5,893 with both BCS and DO records) from 97 herds and 30,081 BCS records in lactation 1, 22,545 BCS records in lactation 2, 15,102 BCS records in lactation 3 and 21,463 DO records for the 3 first lactations. The analysis for BCS and 305MY, 305FY and 305PY included 12,802 cows (of which 5,921 with both BCS and production records) from 88 herds and 27,928 BCS records

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in lactation 1, 20,962 BCS records in lactation 2, 14,000 BCS records in lactation 3 and 23,615 production traits for the 3 first lactations. Finally, pedigree data were limited to animals born after 1985.

Models. Four 4-traits (BCS in lactation 1, BCS in lactation 2, BCS in lactation 3, and one of the traits of interest (DO, 305MY, 305FY, and 305PY) including records of the 3 first parities) models were run. The following model was used:

$$y = X\beta + Hh + Wc + Zp + Za + e$$

where:

- y was the vector of observations (BCS in lactation 1, BCS in lactation 2, BCS in lactation 3, and one of the following traits including records of the 3 first parities: DO, 305MY, 305FY, and 305PY);
- β was the vector of the following fixed effects: for BCS, 1) class of age at calving \times class of 14 DIM, 2) herd \times BCS scoring date; for DO, 305MY, 305FY, and 305PY, 1) year of calving \times month of calving \times parity number, 2) season of calving \times class of age at calving \times parity number, 3) herd \times parity number;
- h was the vector of the herd \times year of calving random effect for DO, 305MY, 305FY, and 305PY;
- c was the vector of BCS recorder random regression coefficients for BCS;
- p was the vector of permanent environmental random regression coefficients for BCS and the vector of permanent environmental random effect for DO, 305MY, 305FY, and 305PY;
- a was the vector of genetic additive random regression coefficients for BCS and the vector of genetic additive random effect for DO, 305MY, 305FY, and 305PY;
- e was a vector of residuals;
- X, H, W, Z were incidence matrices assigning observations to effects.

Classes of age at calving were defined within lactation. Four seasons of calving were defined as December to February, March to May, June to August, and September to November. Regression curves were modeled using Legendre polynomials of order 2. The covariance matrices for environmental and additive genetic effects combined the variance of DO or production traits, the (co)variance for random regression components for BCS and the covariance between the DO or production trait and random regression components for BCS. Random effects were assumed to be normally distributed and residual variances were assumed to be independent and constant over the lactation. (Co)variance estimation was performed using expectation maximization (EM)-REML. Heritabilities were defined as the ratio of genetic variance to the sum of all random effects variances. Heritabilities for BCS were averaged across the 4 analyses. Genetic correlations between BCS and the others traits were obtained as the diagonal of QGQ' , where G represented the genetic additive covariance matrix and Q was a 20×3 matrix containing Legendre polynomials coefficients computed for DIM 5 to 305 with increment of 15 days.

Results and discussion

Heritabilities. Daily heritability for BCS ranged between 0.09 and 0.23 in lactation 1, between 0.08 and 0.25 in lactation 2, and between 0.11 and 0.35 in lactation 3. It increased from 5 to 200 DIM and then decreased until 305 DIM. Averaged daily heritabilities for BCS

were 0.19 in lactation 1, 0.21 in lactation 2 and 0.29 in lactation 3. Heritability estimates were 0.06 for DO, 0.30 for 305MY, 0.29 for 305FY, and 0.26 for 305PY.

Genetic correlations. Genetic correlations over the lactation between BCS in lactation 1, lactation 2, and lactation 3 with the 4 traits of interest are shown in Figure 1; averaged estimates are presented in Table 1. Genetic correlations between DO and BCS were negative, moderate and did not differ strongly within and across the three lactations; they ranged between -0.46 and -0.62 and slightly decreased over the lactation. It indicated that a genetically low BCS was associated with increased number of days when the cow was not pregnant. Bastin et al. (2010) presented weaker genetic correlations between BCS and DO for first parity Holstein cows ranging from -0.31 at 200 DIM to -0.14 at 5 DIM. Moreover estimates from previous studies assessing genetic correlations between BCS and interval fertility traits using random regression model were in the same range (Veerkamp et al., 2001; De Haas et al., 2007) or slightly weaker (Berry et al., 2003) than our results. Genetic correlations between BCS and 305MY, 305FY and 305 PY were negative, low to moderate, ranging from -0.16 to -0.71; they were generally weaker for BCS in first lactation, especially for 305MY. They indicated an unfavorable genetic relationship between BCS and yields. They also suggested that selection on high lactation yields (especially for milk yield) has less effect on BCS in first lactation than in later parities. Trends and ranges of correlations between BCS in first lactation and 305MY, 305FY and 305PY were similar to the results presented by Veerkamp et al. (2001) but different from the estimates of Pryce and Harris (2006) who undertook their study on data of first lactation cows from the specific pasture based system of New Zealand.

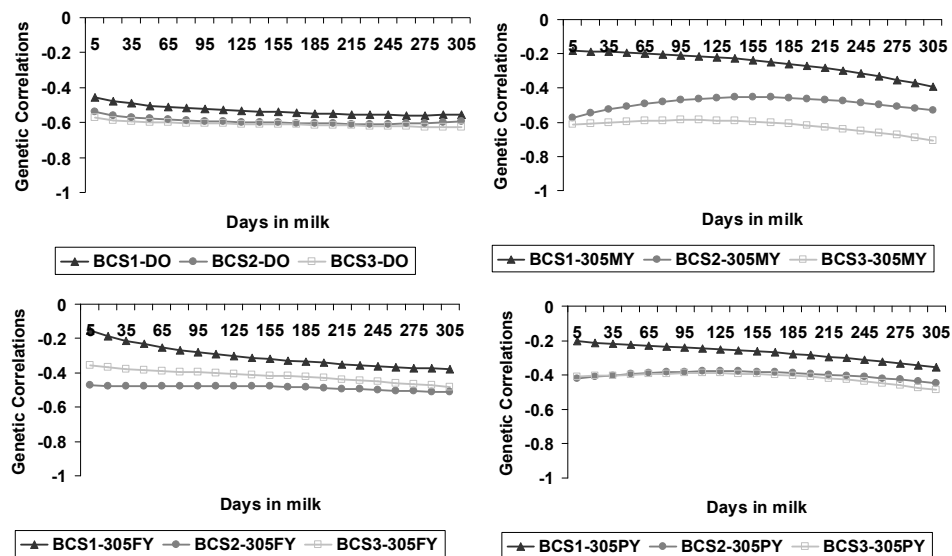


Figure 1: Genetic correlations over the days in milk between body condition score in lactation 1 to 3 (BCS1, BCS2, BCS3) and days open (DO), 305-days milk yield (305MY), 305-days fat yield (305FY) and 305-days protein yield (305PY).

Table 1: Averaged genetic correlations between body condition score in lactation 1 to 3 (BCS1, BCS2, BCS3) and days open (DO), 305-days milk yield (305MY), 305-days fat yield (305FY) and 305-days protein yield (305PY).

Traits	BCS1	BCS2	BCS3
DO	-0.53	-0.59	-0.61
305MY	-0.25	-0.49	-0.62
305FY	-0.12	-0.49	-0.42
305PY	-0.27	-0.40	-0.42

Conclusion

Results of this research realized on multiparous Holstein Walloon cows indicated moderate favorable genetic correlations between BCS and fertility and unfavorable genetic correlations between BCS and lactation yields for fat, protein and milk. They suggested that BCS could be used for an indirect selection on fertility. However, such a selection should be achieved considering its deleterious effects on milk, fat and protein yields, especially in parities greater than 1. Therefore, future research is warranted for developing a BCS breeding values expressed as an indicator providing the best genetic gain for fertility.

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